AOSN MURI: UTILITY ACOUSTIC MODEM COMPONENT

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LONG-TERM GOALS

To create and demonstrate a reactive survey system, capable of long-term unattended deployments in harsh environments. We refer to such a system as an Autonomous Ocean Sampling Network (AOSN). The goals for this year on the Utility Acoustic Modem (UAM) component of the MURI were to develop and evaluate a complete prototype modem and then demonstrate this, in conjunction with other AOSN system components, in an at-sea engineering trial.

ACCOMPLISHMENTS

Work on the UAM program in 1996 led to the development of a specification for the modem, based on consultation with potential users. This year, a prototype UAM has been developed from this specification. The UAM consists of a set of three boards: the main board, an input board, and a power amplifier board. The main board contains the digital signal processor (a 60 MHz TMS320c44) together with high speed RAM, non-volatile storage, acquisition hardware and time-keeping hardware (Figure 1). The board measures 8” by 3.5” and is an 8-layer circuit board. The approximate cost of the board and components is $1,250. Two iterations of this board were produced this year: an experimental version, V1.0, and the final prototype, V1.1.

The input board and power amplifier boards each measure approximately 3.5” by 3.2” and are designed to be mounted above the main board. As both of these boards involve some application-specific components, relating to hydrophone conditioning and source matching, low cost construction and components were used in each case. The power amplifier board is a two-layer board with component cost of less than $100. The input board is a four-layer board with component cost less than $200.

Evaluation of the prototype board set is nearly complete with excellent results being obtained. The device meets the design specifications and exceeds them in some important respects. Of particular note are: 1) the power consumption of the prototype is approximately one-half of the anticipated value (less than 4 Watts instead of 8 Watts during receive operations), and 2) the operating supply voltage range (5.5V to 20V) is wider than specified allowing a wider range of battery power sources. Another important specification, the noise performance of the acquisition sub-system, has been found to be completely satisfactory with a dynamic range, including the programmable gain front-end amplifier, in excess of 100dB.

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A pressure housing and chassis has been designed for the UAM allowing operation at depths up to 3.5km, as required for the 1998 Labrador Sea deployment. The housing is fabricated from aluminum tube with an inner diameter of 3.5” and outside dimensions of 12.5” long by 4” diameter with a 5” diameter at the end caps. The housing holds both the UAM board set and a 300 watt-hour lithium battery pack allowing up to 75 hours of receive operation without external power. The housing has connectors for a hydrophone array (1 to 4 elements), a source, the data terminating equipment (e.g., an instrument or AUV computer), and a remote configuration port.

The software development for the UAM, started last year, has continued in parallel with the hardware development. Three areas of development have been focused on this year: porting the AMS software system to the UAM; developing a remote host interface for UAM configuration; and communications algorithm development.

The AMS operating system, originally developed under ONR and ARPA funding for an earlier generation modem, has proven to be a flexible and time-saving method for prototyping real-time algorithms. AMS is currently used by a number of groups at WHOI as well as colleagues in other institutions and the software has been ported to a range of hardware implementations. The key new feature of the UAM in terms of porting AMS is that it does not have a permanent host - all previous AMS implementations have utilized a PC or workstation connected to the DSP. For reasons of size and power consumption, the UAM uses a completely embedded design and does not contain a PC host. As a result, the AMS port to the UAM involved considerable effort, but the resulting software has the advantages of rapid booting and straight-forward hardware control. In addition to the standard AMS port, a wide range of UAM-specific functions have been added allowing user control of power consumption and the external interface together with functions for diagnostics, time-keeping, and log-keeping. Finally, AMS functions for driving the UAM power amplifier have been developed. To achieve high efficiency, the power amplifier uses a switching (Class D) technique and so calls for a special suite of control functions.

A second area of software development this year has been in porting the host interface program used with AMS. This program allows interactive operation of AMS via a PC giving the modem access to the host file system and permitting configuration of the modem. Previously the host program required a parallel interface to the modem, and so was ill-suited for remote use with the UAM. Re-writing this software for use with a serial interface, performed by a summer student, has proven to be a pivotal improvement allowing complete configuration of the UAM in the field through a 3-wire interface using a low-cost laptop computer.

Finally in software development, work has continued in the design and implementation of robust, low complexity communications algorithms. Much of this work was led by our Northeastern colleagues and is the subject of a related report. However, research in autonomous receiver design for coherent signaling has continued at WHOI focusing on improved robustness to Doppler shift and on the use of minimal computation adaptation algorithms. Papers on these topics were presented at two international conferences and by invitation at an underwater acoustics workshop.

Following the successful evaluation of the prototype UAM, twelve complete modems are now being fabricated using funding obtained from ONR under the DURIP program. These modems each include the 3-board set, a deep water pressure housing, and a lithium battery pack. The modems will form part of the Modem Pool held at WHOI for use by AOSN colleagues and other researchers interested in acoustic communications. Currently five of the twelve modems are fully tested and in operation. The remainder will be completed and tested in November.

The first at-sea test of the UAM took place in October as part of the AOSN engineering trial. Testing was performed at a shallow water site (near Martha's Vineyard) and a deep water site (Site D). Five UAMs from the Modem Pool were used in this experiment and we are pleased to report no losses, or board or pressure housing failures. Highlighting the versatility of the device, UAMs were used for USBL homing on Odyssey AUVs, as coherent and incoherent signaling transmitters, and as a beacon. Selection of the operating mode of each UAM was achieved through the host port and so did not require dismantling the modems.

RESULTS

The key results of the engineering tests of the UAM are twofold. First, UAMs performed as a complete replacement of the PC Modem used for USBL homing in the Odyssey with no apparent change in homing performance. The power consumption of the UAM is almost 1/10th of the PC Modem and it occupies less than 1/4 of the volume as a board set in the Odyssey spheres. More importantly, the reliability of the UAM was vastly superior to the PC Modem. The Odyssey group has retained two UAMs from the Modem Pool for continuing vehicle tests.

The second engineering result pertains to the acoustic communications evaluation. A drifter incorporating a UAM transmitter was used to test a set of robust communications algorithms at Site D. The signals were received at the ship and recorded on an 8-track digital recorder for off-line analysis. Both coherent and incoherent signaling strategies were tested and the efficient transmission performance of the UAM enabled a high-duty-cycle transmission duration of six hours with a small battery pack. Decoding of the received data performed by Preisig and Brady (Northeastern University) as part of their (WHOI) related MURI effort.

The results and the reliability of the UAM during the engineering deployment make us feel confident that the UAM will be a valuable and fully-functional component of the Labrador Sea deployment in January 1998. In addition to participation in this deployment, work on the UAM project in 1998 will focus on 1) continued implementation and evaluation of robust communications algorithms, 2) the development of higher level protocols such as automatic signal selection, re-transmitting, and a modem command set, 3) long-term deployment of several UAMs to establish failure modes, 4) development of a micro-power detector board for acoustic wakeup of the UAM, and 5) user support in the form of remote configuration tools, a user manual, and on-line information.

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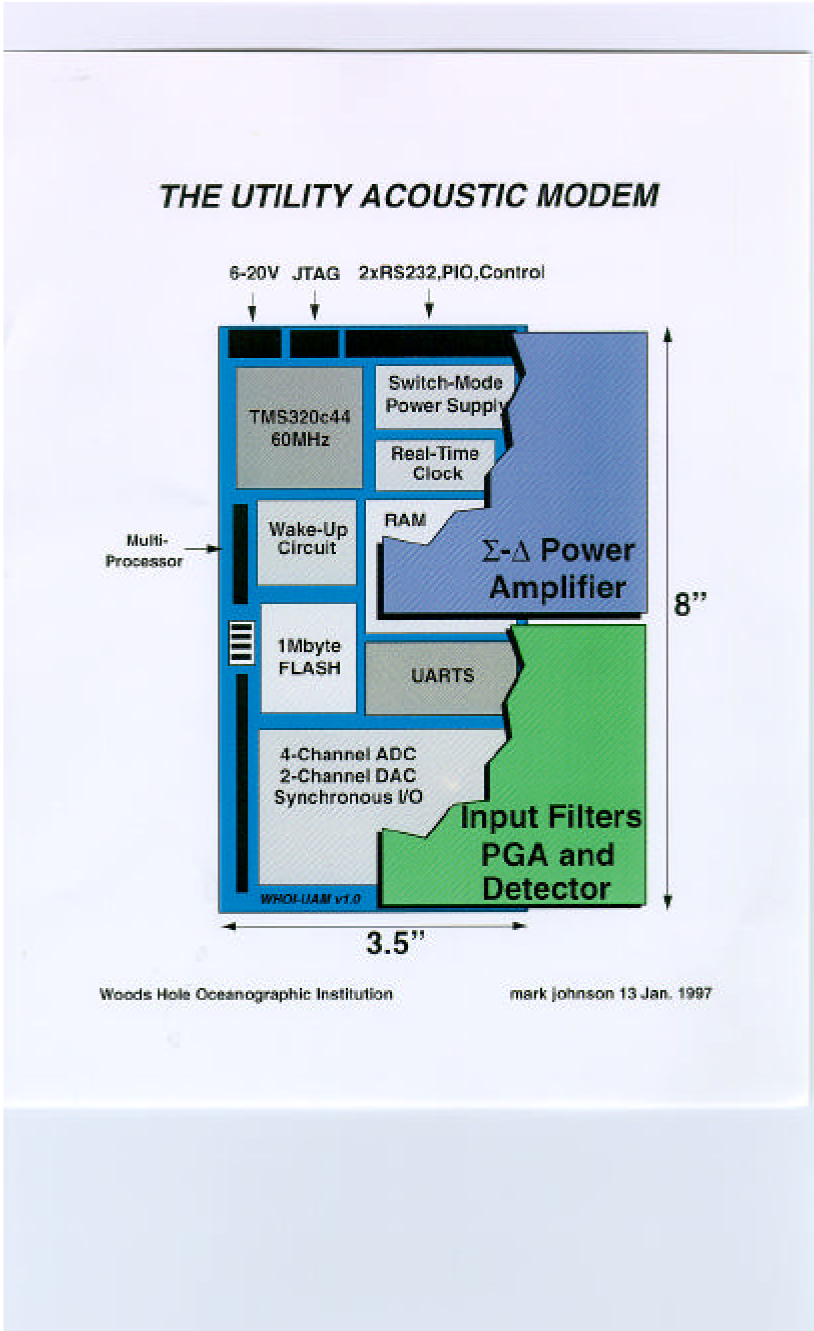
THE UTILITY ACOUSTIC MODEM
6-20V
JTAG
2xRS232,PIO,Control
Switch-Mode Power Supply
TMS320c44 60MHz
Real-Time Clock
Multi-Processor
Wake-Up Circuit
RAM
Σ-Δ Power Amplifier
8"
1Mbyte FLASH
UARTS
4-Channel ADC
2-Channel DAC
Synchronous I/O
Input Filters PGA and Detector
WHOI-UAM v1.0
3.5"
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Figure 1